

What Is Claimed Is:

1. A method for fabricating a filament for use in tissue engineering, said method comprising:

5 providing a polycaprolactone material;

melting said polycaprolactone material at a first given temperature to form a polycaprolactone melt;

holding the temperature of said polycaprolactone melt at said first given temperature for a given
10 amount of time;

lowering the temperature of said polycaprolactone melt from said first given temperature to a second given temperature after the step of holding the temperature of said polycaprolactone melt at said
15 first given temperature for said given amount of time;

extruding said polycaprolactone melt through a fiber-spinning machine, said fiber-spinning machine having spinnerets with a die exit of a given diameter, a piston set at a given speed, and a vertical drop of
20 a given distance from said die exit to a cooling material positioned below said die exit, wherein the

combination of said second given temperature, said
given die exit diameter, said given piston speed, and
said given distance of said vertical drop produces
said filament with a given diameter for use in tissue
5 engineering.

2. A method for fabricating a filament for use
in tissue engineering according to claim 1 wherein
said given diameter of said filament corresponds to
10 drive wheels of an unmodified Fused Deposition
Modeling (FDM) system.

3. A method for fabricating a filament for use
in tissue engineering according to claim 2 wherein
15 said filament is configured to have a constant
diameter.

4. A method for fabricating a filament for use
in tissue engineering according to claim 1 wherein
20 said filament is vacuum-dried prior to usage.

5. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said filament is kept in a dessicator prior to usage.

5 6. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said filament is vacuum-dried and kept in a dessicator prior to usage.

10 7. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said polycaprolactone material as initially provided is in the form of pellets.

15 8. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said first given temperature is about 190° C.

20 9. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said given amount of time is about 15 minutes.

10. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said second given temperature is about 140° C.

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11. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said given diameter of said die exit is about 1.63 mm.

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12. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said given speed of said piston is set at about 10 mm/min.

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13. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said given distance of said vertical drop from said die exit to said cooling material is about 40 mm.

14. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said cooling material is water.

5 15. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said given diameter of said filament includes a range of about 1.60 mm to about 1.80 mm.

10 16. A method for fabricating a filament for use in tissue engineering according to claim 1 wherein said given diameter of said filament is about 1.70 mm.

15 17. A method for fabricating a filament for use in tissue engineering, said method of fabricating said filament comprising:

 providing polycaprolactone pellets;

 melting said polycaprolactone pellets at about 190° C to form a polycaprolactone melt;

20 holding the temperature of said polycaprolactone melt at about 190° C for about 15 minutes;

lowering the temperature of said polycaprolactone melt from said first given temperature to about 140° C after the step of holding the temperature of said polycaprolactone melt at about 190° C for about 15

5 minutes; and

extruding said polycaprolactone melt through a fiber-spinning machine, said fiber-spinning machine having spinnerets with a die exit of about 1.63 mm, a piston set at about 10 mm/min, and a vertical drop of
10 about 40 mm from said die exit to water positioned below said die exit, wherein the combination of said lower temperature of about 140° C, said die exit diameter of about 1.63, said piston speed of about 10 mm/min, and said vertical drop of about 40 mm
15 produces said filament with a given diameter for use in tissue engineering;

wherein said given diameter of said filament corresponds to drive wheels of an unmodified Fused Deposition Modeling (FDM) system;

20 wherein said filament is configured to have a constant diameter; and

wherein said filament is vacuum-dried and kept in a dessicator prior to usage.

18. A method for fabricating a filament for use
5 in tissue engineering, said method comprising:

providing a polycaprolactone material;

drying said polycaprolactone material at a first given temperature for a first given amount of time to form a dried polycaprolactone material;

10 combining said dried polycaprolactone material with a HA and methylene chloride mixture to form a PCL/HA blend;

stirring said PCL/HA blend at a second given temperature for a second given amount of time to form
15 a solvent mixture;

casting said solvent mixture on a tray at a third given temperature for a third given amount of time to evaporate said solvent mixture to form a PCL/HA composite foam material;

20 melting said PCL/HA composite foam material at a fourth given temperature to form a PCL/HA melt;

holding the temperature of said PCL/HA melt at
said fourth given temperature for a fourth given
amount of time;

lowering the temperature of said PCL/HA melt from
5 said fourth given temperature to a fifth given
temperature after the step of holding the temperature
of said PCL/HA melt at said fourth given temperature
for said fourth given amount of time; and

extruding said PCL/HA melt through a
10 fiber-spinning machine, said fiber spinning machine
having spinnerets with a die exit of a given diameter,
a piston set at a given speed, and a vertical drop of
a given distance from said die exit to a cooling
material positioned below said die exit, wherein the
15 combination of said fifth given temperature, said
given die exit diameter, said given piston speed, and
said given distance of said vertical drop produces
said filament with a given diameter for use in tissue
engineering.

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19. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said first given temperature during the step of drying said polycaprolactone material is about 40° C.

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20. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said first given amount of time for drying said polycaprolactone is about 24 hours.

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21. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein the step of drying said polycaprolactone material is in a vacuum oven.

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22. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said second given temperature during the step of stirring said PCL/HA blend is about 25° C.

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23. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said second given amount of time during the step of stirring said PCL/HA blend is about 2 hours.

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24. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein the step of stirring said PCL/HA blend is on a platform shaker.

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25. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said third given temperature during the step of coating said solvent on said tray is about 25° C.

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26. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said third given amount of time during the step of casting said solvent on said tray is about 24 hours.

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27. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said tray is formed of glass.

5 28. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said fourth given temperature during the step of melting said PCL/HA composite foam material is about 150° C.

10 29. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said fourth given amount of time during the step of holding the temperature of said PCL/HA melt at said
15 fourth given temperature is about 15 minutes.

20 30. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said given diameter of said die exit is about 1.625 mm.

31. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said given speed of said piston is set at about 1 cm/min.

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32. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said given distance of said vertical drop from said die exit to said cooling material is about 40 mm.

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33. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said cooling material is water.

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34. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein said given diameter of said filament includes a range of about 1.65 mm to about 1.85 mm.

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35. A method for fabricating a filament for use in tissue engineering according to claim 18 wherein

said given diameter of said filament is about 1.75 mm.

36. A method for fabricating a filament for use
in tissue engineering according to claim 18 wherein
5 said filament has a length in the range of about 7.8 m
to about 8.2 m.

37. A method for fabricating a filament for use
in tissue engineering according to claim 18 wherein
10 said filament has a length of about 8.0 m.

38. A method for fabricating a filament for use
in tissue engineering according to claim 18 further
comprising the step of storing said PCL/HA composite
15 foam material in a dessicator prior to the step of
melting said PCL/HA composite foam material so as to
form said filament.

39. A method for fabricating a filament for use
20 in tissue engineering according to claim 18 wherein
said PCL/HA blend has a 25% content of HA.

40. Apparatus for use in tissue engineering,
said apparatus comprising:

a scaffold structure being formed of a plurality
5 of horizontal layers of material;

vertical walls forming each of said plurality of
horizontal layers of material, said walls of each
layer of said plurality of horizontal layers each
having a height, each being horizontally separated
10 from one another, and defining an orientation;

adjacent pairs of said vertical walls of each of
said plurality of horizontal layers of material
forming channels therebetween, said channels having a
depth and a width created by said height of said walls
15 and said horizontal separation of said adjacent pairs
of said vertical walls, respectively;

adjacent layers in said plurality of horizontal
layers of material being in different orientations to
one another wherein said orientation defined by
20 adjacent ones of said each layer of said walls of said
plurality of horizontal layers differ from one

another, said different orientations providing a group
of cross-points to allow adhesion between said
adjacent layers and providing interconnectivity
between said channels throughout said scaffold
5 structure.

41. Apparatus for use in tissue engineering
according to claim 40 wherein said material forming
said scaffold structure is a polycaprolactone
10 filament.

42. Apparatus for use in tissue engineering
according to claim 40 wherein said material forming
said scaffold structure is a
15 polycaprolactone/hydroxyapatite composite filament.

43. Apparatus for use in tissue engineering
according to claim 40 wherein said vertical walls have
a linear shape.

44. Apparatus for use in tissue engineering according to claim 40 wherein said vertical walls have a curved shape.

5 45. Apparatus for use in tissue engineering according to claim 40 wherein said orientation of said walls is a lay-down pattern of linear shaped walls for progressive layers of said plurality of horizontal layers of material with respect to said lay-down
10 pattern for a first horizontal layer.

46. Apparatus for use in tissue engineering according to claim 45 wherein said orientation of said walls is in a lay-down pattern of $0^{\circ}/90^{\circ}$.

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47. Apparatus for use in tissue engineering according to claim 45 wherein said orientation of said walls is in a lay-down pattern of $0^{\circ}/60^{\circ}/120^{\circ}$.

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48. Apparatus for use in tissue engineering according to claim 45 wherein said orientation of said

walls is in a lay-down pattern of
0°/72°/144°/36°/108°.

49. A method for fabricating a customized
5 scaffold structure for use in tissue engineering for
an individual patient, said method comprising:

obtaining a digital scan of an anatomical
component of the individual patent;

obtaining a desired zone of said digital scan of
10 the anatomical component of the individual patent;

converting said desired zone of said digital scan
of the anatomical component of the individual patent
to an Fused Deposition Modeling (FDM) system
compatible format;

15 slicing said desired zone of said digital scan of
said FDM system compatible format into multiple layers
so as to create a sliced model of said customized
scaffold structure for fused deposition modeling;

creating tool path data for fused deposition
20 modeling using said sliced model of said customized
scaffold structure;

exporting said tool path data of said sliced
model of said customized scaffold structure to a Fused
Deposition Modeling (FDM) system; and

5 creating said customized scaffold structure using
said tool path data of said sliced model of said
customized scaffold structure and said Fused
Deposition Modeling (FDM) system.